# Diabetic Infection of the Lower Limb : A Continuing Surgical Problem

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Records of 148 diabetics with lower limb infection treated surgically during 1975-1979 were analysed. The majority presented with acute suppuration or gangrene of the toes and feet. There was usually a long delay in seeking treatment and diabetes was often poorly controlled. The amputation rate was 47.3 per cent and mortality 8.1 per cent. Hospitalization averaged 50.9 days. Surgical aspects of management were discussed. In suppuration and gangrene early and adequate excisional drainage, exploration for deep-seated abscesses, and amputation through uninfected tissue were emphasized. Conservative surgery should be adopted in chronic trophic ulcers. The necessity for proper diabetic control and foot care was also stressed.

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## INTRODUCTION

Diabetes mellitus is a metabolic syndrome involving multiple organs and has numerous complications. One of the commonest complications is infection of the lower limbs, particularly the feet.[1] Care of the diabetic foot has been constantly emphasized in the medical literature and pamphlets given to patients to prevent injury and infection which once established can be very difficult to treat. However, a large number of diabetics with foot problems are still being seen at the Chulalongkorn Hospital. The severity of infection may vary from minor ulceration requiring simple out-patient treatment to serious infection necessitating prolonged hospitalization, multiple operations, and often limb amputation. This article is a review of cases of diabetic infection of the lower limbs treated by the staff of the department of surgery to determine its morbidity, mortality, and demand on the surgical beds. An attempt was made to identify problems encountered in the management of these patients, particularly in the surgical aspects, and to evaluate the causes of infection. It was hoped that more effective treatment and prevention would be evolved from this study.

## MATERIAL AND METHODS

Chulalongkorn Hospital records of diabetic patients admitted for infection of the lower limbs and requiring surgical treatment in the years 1975-1979 were reviewed. Preadmission data concerning the diabetic status, causes of infection, duration, and treatment were determined. Patients were diagnosed or confirmed as diabetics if at least two fasting blood sugar specimens exceeded 140 mg/100 ml. Infection was classified according to the site and severity. Details and results of hospital treatment for diabetes,

infection, and associated diseases were recorded.  Surgical procedures short of limb amputation, including toe amputation, were classified as conservative surgery.  Morbidity, as measured by loss of limbs, and mortality were analysed to determine as far as possible any deficiencies in management.

## RESULTS

One hundred and forty eight diabetic patients with lower limb infection requiring surgical treatment were admitted at the Chulalongkorn Hospital during 1975-1979.  There were 167 admissions, fifteen patients were admitted twice and one patient three times either because of recurrent infection or involvement of the opposite limbs.  There were 67 males and 81 females.  Patients' age ranged from 17 to 85 years with a mean of 56.4 years.  The age distribution is shown in Figure 1.  Ninety four per cent of patients were over 40 years of age.  The length of hospitalization varied from three to 346 days, a mean of 50.9 days.  There were 12 deaths, a mortality of 8.1 per cent.  Eight patients took their own discharge, three having refused limb amputation.

On admission 115 patients (77.7 per cent) were known diabetics, but only 64 (43.2 per cent) received regular treatment or follow up.  Nine patients received insulin, eleven had both insulin and oral hypoglycaemic agents during treatment, and 44 were on oral hy-
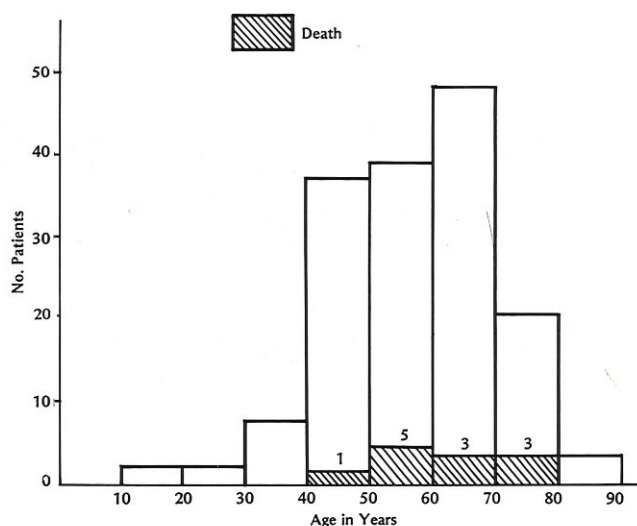


Fig. 1  Age distribution & mortality of 148 patients

poglycaemic agents alone.  Duration of diabetes varied from one month to 30 years, mean 8.6 years.  Diseases associated with diabetes may have been incompletely documented.  However, peripheral neuropathy was recorded in 57 cases (38.5 per cent).  Although ankle pulses were frequently impalpable because of swelling, absence of popliteal pulses was observed in three and femoral pulses in two cases.  Car-

Table 1  Level & Severity of Infection, Morbidity & Mortality

| | No. Cases | Morbidity (Amputation) | | | Mortality |
|---|---|---|---|---|---|
| | | Below knee | Above knee | Hip Disarticulation | |
| *Toes & Feet* | | | | | |
| Gangrene | 68 | 45 | 5 | 1 | 7 |
| Ulcer/abscess | 66 | 16 | — | — | 1 |
| Cellulitis | 3 | — | — | — | — |
| Chronic ulcer | 9 | — | — | — | — |
| Total | 146 | 61 | 5 | 1 | 8 (5.5%) |
| *Legs* | | | | | |
| Gangrene | 5 | — | 4 | — | — |
| Ulcer/abscess | 5 | 2 | — | 1 | 1 |
| Cellulitis | 1 | — | — | — | — |
| Total | 11 | 2 | 4 | 1 | 1 (10%) |
| *Knee & Thighs* | | | | | |
| Gangrene | 1 | — | 1 | — | — |
| Ulcer/abscess | 7 | — | 3 | 1 | 2 |
| Cellulitis | 1 | — | — | — | — |
| Septic arthritis | 1 | — | — | — | 1 |
| Total | 10 | — | 4 | 1 | 3 (30%) |

diovascular diseases were noted in 34 cases (23 per cent), eighteen had hypertension, twelve congestive heart failure, and four myocardial ischaemia. Diabetic nephropathy was noted in 21 cases (14.2 per cent). Cataracts were found in 27 and retinopathy in 13 cases.

Patients presented with lower limb infection of varying levels and severity. The majority presented with either acutely infected ulcers with underlying abscesses or gangrene of the toes and feet. Only nine cases of trophic ulcers were seen. The level and severity of infection together with the morbidity and mortality are shown in Table 1. Gangrenous lesions carried the highest morbidity and mortality. Mortality was also higher the more proximal the infection. Bilateral limb involvement occurred in 25 cases (17 per cent), six patients already had amputation of the contralateral limbs from previous infection. Causes of infection are listed in Table 2. Various forms of trauma and accident were the chief causes although there were no obvious causes in 63 cases. In acute infection there was a delay of three to 100 days, mean 22.3 days, from the time of injury to admission. Chronic trophic ulcers existed for one month to three years, mean 1.6 years, prior to admission. Forty eight cases had treatment for infection at clinics and 25 cases in other hospitals with unsatisfactory results. Ninety four cases (56.3 per cent) seeked no medical advice at all

prior to admission, some treated themselves with traditional medicines.

Treatment for diabetes, infection, and associated diseases were usually started simultaneously on admission. After confirmation of diabetes from blood sugar measurement most patients were initially put on soluble insulin. As diabetes became more stabilized and infection controlled many patients could be changed to the longer acting insulins, oral hypoglycaemic agents, or diet alone. Table 3 summarized the blood sugar values and diabetic treatment at various stages of illness.

Most patients were put on broad-spectrum antibiotics which may be subsequently changed depending on bacterial cultures and clinical course. Results of positive bacterial cultures in 124 cases are shown in Table 4. Mixed organisms were cultured in 73 and single species in 51 cases. Staphylococcus aureus was most frequently cultured followed by the gram-negative bacilli. Anaerobic cultures were not done routinely. Surgical treatment in acutely infected cases was usually given as soon as the patients' diabetes and associated diseases were stabilized. The initial operative treatment usually consisted of open and drainage of pus and debridement of devitalized tissues. Subsequent surgical procedures depended on the surgeons' assessment of the operative findings and patients' progress. Most operations were performed by resident surgeons in training.

Eighty eight cases were treated by conservative surgical procedures. Details and results of treatment are shown in Table 5. The number of operations per patient varied from one to 13, averaging 3.6. The most commonly performed operation was debridement which frequently preceded toe amputation, skin grafting, or suture. All nine cases of trophic ulcers were successfully treated conservatively. Duration of hospitalization in the conservative group varied from four to 169 days, a mean of 45 days.

Seventy nine patients (47.3 per cent) had limb amputation. Hospitalization varied from nine to 346 days, averaging 57.6 days. One patient had bilateral below-knee amputation during the same admission and three others already had the contralateral limbs amputated previously, thus resulting in four bilateral

### Table 2 Causes of Infection

| Causes | No. Cases |
|---|---|
| Trauma | 45 |
| Chronic trophic ulcer | 18 |
| Cutting corns/surgery | 10 |
| Burns | 8 |
| Ill-fitting shoes | 7 |
| Ischaemia | 6 |
| Nail infection | 4 |
| Wading through floods | 4 |
| Insect bites | 2 |
| No obvious causes | 63 |

### Table 3 Blood Sugar Values & Diabetic Treatment.

| | Blood Sugar (mg/100 ml) | | Diabetic Treatment (No. Cases) | | | |
|---|---|---|---|---|---|---|
| | Range | Mean | Insulin | Oral Agents | Diet | None/Irregular |
| Before Admission | | | 20 | 44 | — | 84 |
| Admission | 48-687 | 322.7 | 139 | 18 | 10 | — |
| Discharge | 80-380 | 158.3 | 50 | 83 | 22 | — |
| At Death | 30-416 | 206.1 | 9 | 1 | 2 | — |

**Table 4** Bacteriological Results in 124 Cases with Positive Cultures

| Organisms | No. Cases | |
|---|---|---|
| | Total | Single Species |
| Staphylococcus aureus | 46 | 12 |
| Proteus species | 37 | 13 |
| E. coli | 32 | 6 |
| Enterobacter | 31 | 6 |
| Pseudomonas | 31 | 2 |
| Klebsiella | 24 | 3 |
| Haemolytic streptococcus | 23 | 3 |
| Herellea | 11 | 0 |
| Peptostreptococcus | 8 | 1 |
| Clostridia | 7 | 2 |
| Enterococcus | 6 | 1 |
| Staphylococcus albus | 6 | 1 |
| Non-haemolytic streptococcus | 4 | 0 |
| Bacteriodes fragilis | 4 | 0 |
| Coliform | 3 | 1 |
| Streptococcus faecalis | 2 | 0 |
| Corynbacter | 1 | 0 |
| Diphtheroid | 1 | 0 |

amputees. There were 63 below-knee and 13 above-knee amputations as well as three hip disarticulations. Amputation levels and results are shown in Table 5. Five cases required above-knee amputation after below-knee amputation failed to control infection with one death. Similarly, two hip disarticulations were necessary because lower amputations failed, both patients died. The only survivor of hip disarticulation had 20 subsequent toilet operations and was hospitalized for one year. Twenty one cases received below-knee and three above-knee amputations within 48 hours of admission because of severe infection or gangrene. The other 55 amputations were done 4-81 days after admission usually because conservative procedures failed to control infection. Results of early and late amputations are shown in Table 6. Mortality rates in the two groups were comparable, but stump infection was more frequent in the early amputation group in which stumps were often left open.

One of the two cases with femoral arterial occlusion had gangrene of the toe and was successfully treated by femoro-femoral bypass, sympathectomy, and toe amputation. The other case had gangrene of the foot and required below-knee amputation. One case with popliteal arterial occlusion had superficial ulceration of the foot and was successfully treated conservatively, the other two cases had below-knee amputation for gangrene of the feet.

Of the 12 fatal cases, six were treated conservatively and six by amputation. Uncontrolled sepsis was the sole cause of death or played a major role in 10 cases in which three also suffered from uraemia and one from congestive heart failure. Diabetes was poorly controlled in seven cases before death. Poor surgical judgement played an important contributory role, leading to inadequate surgery or poor timing of amputation. Two cases died from associated ischaemic heart disease.

## DISCUSSION

Although this series represented a selected group of diabetics with lower limb infection managed by general surgeons the magnitude of the problem is

**Table 5** Results of Surgical Treatment

| Procedures | No. Cases | Results | | |
|---|---|---|---|---|
| | | Improved | Self Discharged | Dead |
| *Conservative* | | | | |
| Debridement only | 35 | 26 | 5 | 4 (11.4%) |
| Toe amputation | 28 | 25 | 1 | 2 ( 7.1%) |
| Skin graft | 20 | 20 | — | — |
| Suture | 5 | 5 | — | — |
| Total | 88 | 76 | 6 | 6 ( 6.8%) |
| *Amputation* | | | | |
| Below-knee | 63 | 59 | 2 | 2 ( 3.2%) |
| Above-knee | 13 | 11 | — | 2 (15.4%) |
| Hip disarticulation | 3 | 1 | — | 2 (66.7%) |
| Total | 79 | 71 | 2 | 6 ( 7.6%) |

**Table 6** Results of Early & Late Amputation

|                 | No. Cases | Infected Stumps | Deaths    | Hospita-lization |
|-----------------|-----------|-----------------|-----------|------------------|
| Early Amputation | 24       | 13 (54.2%)      | 2 (8.3%)  | 44.2 (13-92)     |
| Late Amputation  | 55       | 16 (29.1%)      | 4 (7.3%)  | 67.5 (19-346)    |

evident. This diabetic complication affected mainly elderly patients and accounted for approximately 15 per cent of the total bed occupancy of the general surgical unit. The morbidity was high, with an amputation rate 47.3 per cent. Although the hospital mortality was 8.1 per cent, the fates of the eight patients who took their own discharge were unknown, particularly of the three who refused amputation.

Proneness to foot infection in diabetics has been attributed to several factors such as peripheral neuropathy, ischaemia, and possibly reduced resistance to infection. Peripheral neuropathy associated with diabetes has been found in over 90 per cent of cases with foot infection.[2] The incidence of 38 per cent in this series was probably an underestimate either because it was not specifically looked for or fully documented. Neuropathy may impair sensations making the feet more susceptible to acute and chronic injuries. Vasomotor response may also be abnormal if the autonomic nerves are involved in the neuropathy.[3] Ischaemia due to major arterial occlusion was uncommon in this series in contrast to the high incidence in the west.[1,4] However, microangiopathy associated with diabetes[5] may cause local ischaemia impairing wound healing and resistance to infection.[6] Abnormal leucocytic functions have been found in hyperglycaemic serum and may predispose diabetics to infection. Leucocytic abnormalities included impaired chemotaxis,[7] adherence,[8] phagocytosis,[9] and intracellular killing of bacteria.[10] Thus prevention of foot infection is most important since once infection has become established eradication may be difficult and prolonged.

Every patient admitted with foot infection should have the urine and fasting blood sugar examined. Once diabetes mellitus has been confirmed treatment should begin immediately, preferably by surgeons and physicians working closely as a team. Since acute infection and surgery aggravate the diabetic state, patients should initially be put on insulin unless their diabetes is very mild. Those with severe diabetes and ketoacidosis may require intravenous infusion of insulin[11] although none was required in this series. Once infection has been controlled many patients could be changed from insulin to oral hypoglycaemic drugs or

even to diet alone. The overall management of diabetes in surgical patients has recently been reviewed.[12,13]

On admission, bacterial culture should be taken from the wound and broad-spectrum antibiotics started. Bacterial culture in this series as well as other.[1,14] demonstrated a predominance of Staphylococcus aureus and gram-negative bacilli. However, if anaerobic cultures were done routinely Bacteriodes fragilis species could be isolated in 90 per cent of specimens.[15] It therefore appears reasonable to start antibiotics which are effective against Bacteriodes fragilis as well as Staphylococcus aureus and gram-negative bacilli. Since bacterial cultures from the wound surface and from its depth may yield different results,[16] cultures should be repeated especially during operation when deep-seated pus may be obtained. Changes of antibiotics may be required depending on the bacteriological data and the patients' clinical course.

The role of antibiotics should not be overestimated however because the mainstay of treatment of the acutely infected lower limb is prompt surgery as soon as the patient's diabetes and associated diseases have been stabilized. The surgical procedure depends on the severity and site of infection. In superficial infection without any gangrene conservative surgery is usually successful. Although simple cellulitis requires only antibiotics and bed rest with elevation of the leg, severely swollen limb requires multiple incisional drainage and excision of necrotic skin and subcutaneous fat if present. During the initial operation an adequate exploration should be made to exclude any deep-seated abscesses which could easily have been missed by the inexperienced operators.

Acute suppurative infection and gangrene of the feet presented the greatest problem in management in this series, as evidenced by the necessity for multiple operations, prolonged hospitalization, and the high morbidity and mortality. Deficiencies in treatment were most often caused by operations being performed by inexperienced resident surgeons without supervision, inadequate exploration to determine the full extent of infection, inadequate excisional drainage, and limb amputation being done too low or too late.

Gangrene of the toes without web space or forefoot involvement requires toe amputation, preferably through the metatarsal neck. Amputation through the interphalangeal or metatarso-phalangeal joint leaving joint cartilage and fibrous capsule exposed predisposed to a low-grade suppurative infection which often required further excision. Whether the amputation wound should be closed primarily depends on the surgeon's judgement in individual cases. In properly selected cases of toe gangrene, transmetatarsal amputation of the foot can give good results.[17] However, none was carried out in this series mainly because infection had already spread proximally to the feet

in most cases.

Gangrene and suppuration involving the toes, web spaces and forefoot requires an aggressive approach to treatment if the foot is to be saved. Knowledge of the anatomy of the foot is also important. An adequate excisional drainage should be done promptly.[18] This may involve excision of toes and corresponding metatarsals as well as all infected and necrotic skin, fat, muscles, and tendons. A "ray" excision would result from such a procedure. The foot should also be explored to look for infection or abscesses deep to the plantar fascia. Inadequate excisional drainage leads to spreading of infection along musculo-tendinous planes to the proximal foot and ankle. Radiological evidence of osteomyelitis can be misleading[2] because bone resorption may be impaired and rarefraction absent as a result of ischaemia.[19] The excised wound should be left open and irrigated with antiseptic solutions. Soaking of the foot in a bucket of saline or hydrotherapy did not appear to play any beneficial role in this series. In fact prolonged immersion may cause wound oedema and maceration of surrounding skin. Further surgical debridements may be required until the wound becomes lined by healthy granulation tissue ready to be skin grafted or sutured. Enzymatic debridement has not been tried in this series.

Gangrene involving more than the forefoot requires prompt amputation. All such cases in this series had amputations below the knees. Syme amputation had a bad reputation in infected or gangrenous feet although Meggit[20] obtained some successes by employing a two-stage Syme procedure. Gangrene of the whole foot requires urgent amputation. Standard below-knee amputation, if carried out meticulously through uninfected tissue, has a good chance of healing per primum because major arterial occlusion is uncommon. In general, the proper level for amputation depends on careful evaluation of several factors such as the extent of infection, local blood supply, and the patient's condition.[21] In this series some cases with gangrene and cellulitis spreading up the legs had guillotine amputation below the knees instead of above-knee amputation. Guillotine amputation through inflamed and oedematous tissue required subsequent revision operations and often higher amputations because of stump infection. In an attempt to preserve the knee at all cost the patient's life can be put in jeopardy. In fact, four deaths from sepsis in this series were directly due to amputations being done too low or too late. Although it is justifiable to try to preserve the knee if there is a reasonable chance of success, amputation in elderly and frail diabetics should be carried out through healthy and uninflamed tissue to ensure primary healing even though an above-knee amputation may be required. Below-knee amputees generally coped better than above-knee amputees,[22] but less than half of all diabetics with below-

knee amputation could walk with prostheses and their life expectancy was also poor.[23] Thus the primary aim in treating elderly diabetics with lower limb gangrene should be to save life from sepsis by prompt amputation to promote primary healing, shorten hospitalization, and provide early rehabilitation. Once suppuration and gangrene has spreaded up to the thigh mortality is even greater, as seen in patients who had above-knee amputation and hip disarticulation in this series.

Trophic ulcers may occur on pressure points on the toes, under the metatarsal heads, or on the heels as a result of peripheral neuropathy.[24] Bed rest, antibiotics, and dressings with antiseptics should be the initial treatment in uncomplicated trophic ulcers. Once inflammation has subsided, conservative surgery may be required and is usually successful as seen in the small number of cases in this series. Similarly good results were obtained by others using a variety of procedures which included toe amputation,[2] excision of metatarsal head under the ulcer,[25] and transmetatarsal amputation of the foot.[17]

Infection of the feet was found to have a better chance of healing without amputation if the feet had a good blood supply.[14] Vascular reconstruction should be carried out if feasible in cases with major arterial occlusion.[26] However, the immediate prognosis of the limbs in cases with femoro-popliteal occlusion in this series appeared to be determined more by the severity and extent of infection rather than by the local blood supply.

Proper control of diabetes[27] and meticulous care of the feet to prevent ulceration and infection[1] have been constantly emphasized. In this series approximately one fourth of patients did not know they were diabetic and less than half of all patients received regular diabetic treatment. It is also evident that in the majority infection could be prevented if proper care of the feet was practiced. It is beyond the scope of this article to give details of diabetic foot care. However, avoidance of walking bare-footed, wearing of socks and properly fitting shoes, avoidance of cutting corns or warts by unqualified persons, proper cutting of nails, and keeping the skin of the feet clean and moist must be emphasized. Once injury or infection has occurred medical attention should be sought immediately. Lack of public health education and poor socio-economic status are probably responsible for this sad neglect. At present it is up to the physicians and nurses involved in caring for diabetics to provide this education. Many elderly diabetics are unable to look after themselves either because of weakness, poor eye sight, associated diseases, or previous amputation. Thus relatives looking after the patients should also be properly instructed. It is only through prevention that the morbidity and mortality of diabetic infection of the lower limb as well as the burden on the surgical services could be lessened.

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